FORM PTO-1390 U.S DEPARTMENT OF COMMERCE PATENT AND TRADEMARK OFFICE
(REV. 10-2000)

ATTORNEY'S DOCKET NUMBER
514453-3853

TRANSMITTAL LETTER TO THE UNITED STATES DESIGNATED/ELECTED OFFICE (DO/EO/US) CONCERNING A FILING UNDER 35 U.S.C. 371

U.S. APPLICATION NO (If known see 37 C F.R 1.5)
09/700517

INTERNATIONAL APPLICATION NO	INTERNATIONAL FILING DATE	(EARLIEST) PRIORITY DATE CLAIMED
PCT/EP99/03437	**MAY 19, 1999**	**MAY 20, 1998**

TITLE OF INVENTION **MONOSTABLE FERROELECTRIC ACTIVE-MATRIX DISPLAY**

APPLICANT(S) FOR DO/EO/US **Hans-Rolf DÜBAL, Rainer WINGEN and Toshiaki NONAKA**

Applicants herewith submit to the United States Designated/Elected Office (DO/EO/US) the following items and other information:

1. ☒ This is a **FIRST** submission of items concerning a filing under 35 U.S.C. 371.

2. ☐ This is a **SECOND** or **SUBSEQUENT** submission of items concerning a filing under 35 U.S.C. 371.

3. ☒ This is an express request to promptly begin national examination procedures (35 U.S.C. 371(f)).

4. ☒ The US has been elected by the expiration of 19 months from the priority date (PCT Article 31).

5. ☒ A copy of the International Application as filed (35 U.S.C. 371(c)(2))

    a. ☒ is attached hereto (required only if not communicated by the International Bureau).
    b. ☐ has been communicated by the International Bureau.
    c. ☐ is not required, as the application was filed in the United States Receiving Office (RO/US).

6. ☒ An English language translation of the International Application as filed (35 U.S.C. 371(c)(2)).

7. ☒ Amendments to the claims of the International Application under PCT Article 19 (35 U.S.C. 371(c)(3))

    a. ☐ are attached hereto (required only if not communicated by the International Bureau).
    b. ☐ have been communicated by the International Bureau.
    c. ☐ have not been made; however, the time limit for making such amendments has NOT expired.
    d. ☒ have not been made and will not be made.

8. ☐ A English language translation of the amendments to the claims under PCT Article 19 (35 U.S.C. 371(c)(3)).

9. ☐ An oath or declaration of the inventor(s) (35 U.S.C. 371(c)(4)).

10. ☒ An English language translation of the annexes to the International Preliminary Examination Report under PCT Article 36 (35 U.S.C. 371(c)(5)).

Items 11 to 16 below concern document(s) or information included:

11. ☐ An Information Disclosure Statement under 37 CFR 1.97 and 1.98.

12. ☐ An assignment document for recording. A separate cover sheet in compliance with 37 CFR 3.28 and 3.31 is included.

13. ☒ A FIRST preliminary amendment.

    ☐ A SECOND or SUBSEQUENT preliminary amendment.

14. ☐ A substitute specification.

15. ☐ A change of power of attorney and/or address letter.

16. ☐ Other items or information:

    PCT/IB/304, 402

    PCT/ISA/210, PCT/IPEA/416, 409

EXPRESS MAIL

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Date of Deposit: **November 16, 2000**

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Charles Jackson
(Typed or printed name of person mailing paper or fee)

Charles Jackson
(Signature of person mailing paper or fee)

U.S. APPLICATION NO.(If known, see 37 C.F.R. 1 50)	INTERNATIONAL APPLICATION NO.	ATTORNEY'S DOCKET NO.
09/700517	**PCT/EP99/03437**	**514453-3853**

17.☒ The following fees are submitted   (CALCULATIONS /PTO USE ONLY

Basic National Fee (37 CFR 1.492(a)(1)-(5):

Neither international preliminary examination fee (37 CFR 1.482)
nor international search fee (37CFR 1.445(a)(2) paid to USPTO
and International Search Report not prepared by the EPO or JPO.. ... . **$1,000.00**

International preliminary examination fee (37 C F.R. 1.482) not paid to
USPTO but International Search Report prepared by the EPO or JPO.. .... **$ 860.00**

International preliminary examination fee (37 CFR 1.482) not paid to USPTO but
international search fee (37 CFR 1.445(a)(2)) paid to USPTO.. .... **$ 710.00**

International preliminary examination fee paid to USPTO (37 CFR 1.482)
but all claims did not satisfy provisions of PCT Article 33(1)-(4 . ... **$ 690.00**

International preliminary examination fee paid to USPTO (37 CFR 1.482)
and all claims satisfied provisions of PCT Article 33(1)-(4) .... **$ 100.00**

ENTER APPROPRIATE BASIC FEE AMOUNT =   **($ 860.00**

Surcharge of **$130.00** for furnishing the oath or declaration later than ☐ 20 ☐ 30 months from the earliest claimed priority date (37 CFR 1.492(e)).				($
6 Claims /Number Filed /		Number Extra	/Rate	($
Total Claims / **6** - 20 = /		**0**	/X **$18.00**	($
Independent Claims / **1** - 3 = /		**5**	/X **$80.00**	($
MULTIPLE DEPENDENT CLAIM(S) (if applicable)			/+ **$270.00**	($

TOTAL OF ABOVE CALCULATIONS =   **($ 860.00**

☐ Applicant claims small entity status. See 37 C.F.R. 1.27. The fees indicated above
are reduced by ½.   **($**

SUBTOTAL =   **($ 860.00**

Processing fee of **$130.00** for furnishing the English translation later than ☐ 20 ☐ 30
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TOTAL NATIONAL FEE =   **($ 860.00**

Fee for recording the enclosed assignments (37 CFR 1.21(h)). The assignment must be   ($
accompanied by an appropriate cover sheet (37 CFR 3.28, 3.31). **$40.00** per property +   ($

TOTAL FEES ENCLOSED =   **($ 860.00**

(Amount to be: refunded:	$
(charged:	$

a.   ☒ A check in the amount of $8**60.00** to cover the above fees is enclosed.
b.   ☐ Please charge my Deposit Account No. _____ in the amount of $_____ to cover the above fees.
    A duplicate copy of this sheet is enclosed.
c.   ☒ The Commissioner is hereby authorized to charge any additional fees which may be required, or credit any overpayment to Deposit Account No. **50-0320**. A duplicate copy of this sheet is enclosed.

NOTE: Where an appropriate time limit under 37 CFR 1.494 or 1.495 has not been met, a petition to revive (37 CFR 1.137(a) or (b)) must be filed and granted to restore the application to pending status.

SEND ALL CORRESPONDENCE TO:

_____
SIGNATURE

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  William F. Lawrence
NAME

Dated: November 16, 2000

  28,029
REGISTRATION NUMBER

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Applicant(s)   :   DÜBAL et al.

U.S. Serial No.   :   Filed Concurrently Herewith

Int'l Appln. No.   :   PCT/EP99/03437

Int'l Filing Date   :   19 May 1999

Earliest Priority Date :   20 May 1998

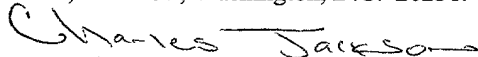For   :   MONOSTABLE FERROELECTRIC ACTIVE-MATRIX
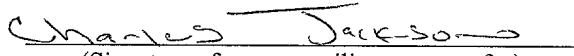   DISPLAY

745 Fifth Avenue
New York, NY 10151

PRELIMINARY AMENDMENT

Assistant Commissioner for Patents
Box PCT
Washington, D.C. 20231

Dear Sir:

    Preliminary to the examination of this U.S. national phase application, please enter the

following amendments:

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IN THE CLAIMS:

Please cancel Claims 1-9 and replace them with Claims 10-15:

--10.   A monostable ferroelectric active matrix display, containing a liquid crystal layer in the form of a monodomain with an unambiguously defined direction of the normal z to the layer of the smC* phase, wherein the normal z to the layer and the preferential direction n of the nematic or cholesteric phase (N* phase) form an angle of more than 5°.

11.   The active matrix display as claimed in claim 10 wherein the angle between the normal z to the layer of the smC* phase and the preferential direction n of the nematic or cholesteric phase (N* phase) lies in a range of from 0.5 times to 1.0 times the smC* tilt angle.

12.   The active matrix display as claimed in claim 10 wherein the ferroelectric liquid crystal layer has a phase sequence of

$$I^*-N^*-smC^*$$

where there may be an smA* phase having a range of existence of at most 2°C between the N* phase and the smC* phase.

13.   The active matrix display as claimed in claim 10 wherein the spontaneous polarization of the ferroelectric liquid crystal phase is less than 15 nC/cm^2.

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14. The active matrix display as claimed in claim $_{10}$ wherein, in the liquid crystal layer, the length of the chiral-nematic or cholesteric pitch in a temperature range of at least 2°C above the transition to the smectic phase is more than 50 μm.

15. A process for producing active matrix displays as claimed in claim $_{10}$ in which the liquid crystal layer is introduced into the interspace between a rubbed upper substrate plate and a rubbed lower substrate plate of the active matrix display, the rubbing directions on the upper and lower substrate plates being essentially parallel, and the liquid crystal phase is cooled from the isotropic phase, an electric DC voltage being applied to the display at least during the $N^* \to smC^*$ or $N^* \to smA^* \to smC^*$ phase transition. __

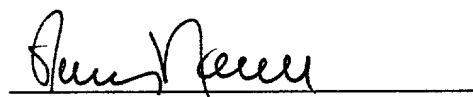## REMARKS

Entry of this amendment and an early examination on the merits are respectfully solicited.

Respectfully submitted,

FROMMER LAWRENCE & HAUG LLP

By: _William F. Lawrence_

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JMM3453

Monostable ferroelectric active matrix display

Replacing the cathode ray tube (picture tube) by a flat screen requires a display technology which simultaneously makes it possible to achieve a high picture resolution, i.e. more than 1000 lines, a high picture brightness (> 200 Cd/m^2), a high contrast (> 100:1), a high frame frequency (> 60 Hz), an adequate color representation (> 16 million colors), a large picture format (> 40 cm screen diagonal), a low power consumption and a wide viewing angle and, moreover, can be produced cost-effectively. Until now, there has been no technology which fully satisfies all these features simultaneously.

Many manufacturers have developed screens which are based on nematic liquid crystals and have been used in recent years in the field of notebook PCs, personal digital assistants and desktop monitors. Use is made here of the technologies STN (Supertwisted Nematics), AM-TN (Active Matrix - Twisted Nematics), AM-IPS (Active Matrix - In Plane Switching), AM-MVA (Active Matrix - Multidomain Vertically Aligned), which are extensively described in the literature, see e.g. T. Tsukuda, TFT/LCD: Liquid Crystal Displays Addressed by Thin-Film Transistors, Gordon and Breach 1996, ISBN 2-919875-01-9 and the literature cited therein; SID Symposium 1997, ISSN-0097-966X, pages 7 to 10, 15 to 18, 47 to 51, 213 to 216, 383 to 386, 397 to 404, and the literature cited therein. Furthermore, use is made of the technologies PDP (Plasma Display Panel), PALC (Plasma Addressed Liquid Crystal), ELD (Electro Luminescent Display) and FED (Field Emission Display), which are likewise explained in the SID report cited above.

Clark and Lagerwall (US 4,367,924) have been able to show that the use of ferroelectric liquid crystals (FLCs) in very thin cells results in opto-electrical switching or display elements which have switching times which are faster by a factor of up to 1000 compared with conventional TN ("twisted nematic") cells, also see EP-A 0 032 362. On the basis of this and other favorable properties, e.g. the possibility of bistable switching and the fact that the contrast is virtually independent of the viewing angle, FLCs are fundamentally suitable for areas of application such as computer displays and television sets, as shown by a monitor marketed in Japan by Canon since May 1995.

The use of FLCs in electro-optical or fully optical components requires either compounds which form smectic phases and are themselves optically active, or the induction of ferroelectric smectic phases by doping compounds which, although forming such smectic phases, are not themselves optically active, with optically active compounds. In this case, the desired phase should be stable over the broadest possible temperature range.

The individual pixels of an LC display are usually arranged in an x-y matrix formed by the arrangement of a respective series of electrodes (conductor tracks) along the rows and columns on the lower or upper side of the display. The points of intersection of the horizontal (row) and vertical (column) electrodes form addressable pixels.

This arrangement of the pixels is usually referred to as a passive matrix. For addressing, various multiplex schemes have been developed, as described for example in Displays 1993, vol. 14, No. 2, pp 86-93 and Kontakte 1993 (2), pp. 3-14. Passive matrix addressing has the advantage of simpler production of the display and associated low production costs, but the disadvantage that passive addressing can only ever be effected line by line, which results in the addressing time for the entire screen with N lines being N times the line addressing time. For customary line

addressing times of approximately 50 microseconds, this means a screen addressing time of approximately 60 milliseconds in e.g. the HDTV standard (High Definition TV, 1152 lines), i.e. a maximum frame frequency of approximately 16 Hz. The latter frequency is too low for the representation of moving images. In addition, the representation of gray shades is difficult. On the occasion of the FLC Conference in Brest, France (July 20-24, 1997, see Abstract Book 6th International Conference on Ferroelectric Liquid Crystals, Brest/France), Mizutani et al. presented a passive FLC display with digital gray shades in which each of the RGB pixels (RGB = red, green, blue) was subdivided into sub-pixels, thereby allowing the representation of gray shades in digital form by means of partial switching. With N gray shades using three primary colors (red, green, blue), 3^N colors are produced. The disadvantage of this method is the considerable increase in the number of required screen drivers and thus in the costs. In the case of a screen shown at Brest, three times as many drivers were required as in the case of a normal FLC display without digital gray shades.

In so-called active matrix technology (AMLCD), a non structured substrate is usually combined with an active matrix substrate. An electrically non linear element, for example a thin-film transistor, is integrated into each pixel of the active matrix substrate. The non linear element may also be diodes, metal-insulator-metal and similar elements, which are advantageously produced by thin-film processes and are described in the relevant literature, see e.g. T. Tsukuda, TFT/LCD: Liquid Crystal Displays Addressed by Thin-Film Transistors, Gordon and Breach 1996, ISBN 2-919875-01-9, and the literature cited therein.

Active matrix LCDs are usually operated with nematic liquid crystals in TN (twisted nematics), ECB (electrically controlled birefringence), VA (vertically aligned) or IPS (in plane switching) mode. In each case, the active matrix generates an electric field of individual strength on each pixel, producing a change in orientation and thus a change in birefringence,

which is in turn visible in polarized light. A severe disadvantage of these processes is the poor video capability caused by the excessively long switching times of nematic liquid crystals.

For this and other reasons, liquid crystal displays based on a combination of ferroelectric liquid crystal materials and active matrix elements have been proposed, see e.g. WO 97/12355 or Ferroelectrics 1996, 179, 141-152, W.J.A.M. Hartmann, IEEE Trans. Electron. Devices 1989, 36, (9;Pt.1), 1895-9, and Dissertation Eindhoven, the Netherlands 1990.

Hartmann utilized a combination of the so-called "quasi-bookshelf geometry" (QBG) of FLC and a TFT (Thin-Film Transistor) active matrix and simultaneously achieved a high switching speed, gray shades and high transmission. However, the QBG is not stable over a wide temperature range, since the temperature dependence of the smectic layer thickness disrupts or rotates the field-induced layer structure. Furthermore, Hartmann utilizes an FLC material having a spontaneous polarization of more than $20 \, nC/cm^2$, which, in the case of pixels having realistic dimensions of e.g. $0.01 \, mm^2$ area, results in large electric charges (at saturation, $Q = 2 \, A \, P$, A = pixel area, P = spontaneous polarization) which, e.g. using amorphous silicon TFTs that can be produced cost-effectively, cannot reach the pixel during the opening time of the TFT. For these reasons, this technology has not been further pursued hitherto.

While Hartmann utilizes the charge-controlled bistability to display a virtually continuous gray scale, Nito et al. have proposed a monostable FLC geometry, see Journal of the SID, 1/2, 1993, pages 163-169, in which the FLC material is oriented with the aid of comparatively high voltages in such a way that only one stable position results, from which a number of intermediate states are then generated by application of an electric field via a thin-film transistor. These intermediate states correspond to a number of different brightness levels (gray shades) when the cell geometry is matched between crossed polarizers.

One disadvantage of this procedure, however, is the occurrence of a streaky texture in the display, which limits the contrast and brightness of this cell (see Fig. 8 in the abovementioned citation). Although the disadvantageous streaky texture can be corrected by treatment with a high electric voltage (20-50 V) in the nematic or cholesteric phase (see p. 168 of the abovementioned citation), such field treatment is not suitable for mass production of screens and, also, generally does not result in temperature-stable textures. Furthermore, this method produces switching only in an angle range of up to a maximum of once the tilt angle, which is approximately 22° in the case of the material used by Nito et al. (see p. 165, Fig. 6) and thus produces a maximum transmission of only 50% of the transmission of two parallel polarizers.

The object of the present invention is to provide a ferroelectric active matrix liquid crystal display containing a ferroelectric liquid crystal mixture, where the liquid crystal mixture assumes a monostable position, but without thereby forming a streaky texture, is temperature-stable and makes it possible to achieve a very high maximum transmission and also a very high contrast.

The object is achieved according to the invention by means of a monostable ferroelectric active matrix display, containing a liquid crystal layer in the form of a monodomain with an unambiguously defined direction of the normal z to the layer of the smC^* phase, where the normal z to the layer and the preferential direction n of the nematic or cholesteric phase (N^* phase) form an angle of more than 5°.

The active matrix FLCD according to the invention contains, as the optically active layer, a ferroelectrically liquid-crystalline medium (liquid crystal phase) with a phase sequence of

isotropic - nematic or cholesteric (N*)- smectic C*

or a phase sequence of

isotropic - nematic or cholesteric (N^*)- smectic A^*- smectic C^*,

where the smectic A^* phase has a range of existence (phase range) of at most 2°C, preferably at most 1°C, particularly preferably at most 0.5°C. The asterisk (*) on the phase designation indicates that a chiral phase is involved.

The displays are produced preferably according to a process in which the liquid crystal layer is introduced into the interspace between a rubbed upper substrate plate and a rubbed lower substrate plate of the active matrix display, the rubbing directions on the upper and lower substrate plates being essentially parallel, and the liquid crystal phase is cooled from the isotropic phase, an electric DC voltage being applied to the display at least during the N^* -> smC^* or N^* -> smA^* -> smC^* phase transition.

The FLC mixture is filled into an active matrix display. The production and the components of such an AM display are extensively described in the Tsukuda literature cited above. Unlike in nematic displays, however, the thickness of the FLC layer is only from 0.7 to 2.5, preferably 1-2 μm. Furthermore, the rubbing directions on the upper and lower substrate plates are essentially parallel. The term "essentially parallel" includes antiparallel rubbing directions, or rubbing directions that are crossed slightly, i.e. up to 10°.

What is important for the functioning of this display, then, is that during the production of the display, during controlled cooling, an electric DC voltage, preferably of less than 5 V, is applied and is maintained during the N^* -> smC^* or N^* -> smA^* -> smC^* phase transition, this causing the entire display to assume a monostable monodomain which appears completely dark between crossed polarizers.

Once this domain has been obtained, the DC voltage is switched off. The texture thus obtained is monostable, in contrast to Hartmann's approach cited above or in contrast to conventional bistable FLCDs. This means that the preferred n-director, (which indicates the preferential direction of the longitudinal molecular axes) is in the rubbing direction of the cell, whereas the z-director (which indicates the preferential direction of the smectic normal to the layer) is inclined relative to the rubbing direction approximately by the amount of the tilt angle. This configuration is exactly the opposite of the usual bistable cell according to Clark and Lagerwall, in which the z-director is in the rubbing direction.

In contrast to Nito's approach, in the case of this orientation there are precisely no two normals to the layer and thus no two orientation domains which ultimately result in the abovementioned disturbing streaky texture, but rather only one unambiguous direction of the z-director and therefore one monodomain. Furthermore, twice the tilt angle, which results in 100% transmission with reference to parallel polarizers, is now available, i.e. double the brightness is attained.

The display thus obtained appears completely dark at a suitable angle of rotation between crossed polarizers. It appears bright when a drive voltage of just a few volts is applied, the brightness being continuously variable by way of the voltage and, at saturation, having virtually the brightness of two parallel polarization sheets. An important feature of this display is that the angle between the preferential direction of the nematic (or cholesteric) phase and the normal to the layer (z-director), is ideally equal to the tilt angle of the smectic C phase, or is at least essentially equal to the tilt angle. "Essentially" in the sense of this invention preferably means a range of values of from half through to the full tilt angle, particularly preferably from 0.8 to 1 times the tilt angle, but at least of 5°.

The ferroelectric active matrix liquid crystal display according to the invention has high practicability, in particular for TV and HDTV or

multimedia, since it combines high transmission, short switching time, gray scale and therefore full color capability, cost-effective production and wide temperature range. Furthermore, the display can be operated at voltages of $\leq$ 10 volts, preferably $\leq$ 8 V, particularly preferably $\leq$ 5 V.

The spontaneous polarization of the active matrix FLCD according to the invention is preferably less than 15 nC/cm^2, preferably in the range of from 0.01 to 10 nC/cm^2 at the operating temperature of the display.

Preferably, in the liquid crystal layer, the length of the chiral-nematic or cholesteric pitch in a temperature range of at least 2°C above the transition to the smectic phase is more than 50 μm.

In particular, active matrix display in the sense of the present invention is also understood to mean an LCD in which one of the two substrates is replaced by the rear side of an IC chip (IC = integrated circuit), as described for example by D.M. Walba, Science 270, 250-251 (1995).

The displays may be used for example in the TV, HDTV or multimedia field or in the field of information processing, e.g. in notebook PCs, personal digital assistants or desktop monitors.

The examples below are intended to illustrate the invention in more detail.

Examples

Example 1

An FLC mixture having the following composition is prepared:

4-(5-dodecylpyrimidine-2-yl)phenyl-4-
(trans-pentylcyclohexane)carboxilic acid ester   27% by weight

2-(4-hexyloxyphenyl)-5-octylpyrimidine   19.7% by weight

2-(4-decyloxyphenyl)-5-octylpyrimidine   25.6% by weight

(S)-2-fluorodecyl-[4-(5-decylpyrimidine-2-yl)
phenyl]ether   3% by weight

The phase sequence is:

isotropic 83.1°C cholesteric 57.7°C smectic A* 57.6°C smectic C*.

The tilt angle is 25° at 30°C. The spontaneous polarization is 2 nC/cm^2.

Example 2

A glass substrate coated with transparent-conductive indium tin oxide is patterned in a photolithographic process to give an electrode pattern. The transparent conductor tracks of this electrode structure are used for electrically driving the display by means of a function generator and the switching behavior of a thin-film transistor is thus simulated. Two glass plates patterned in this way, which form the upper and lower sides of the display - that is to say the supporting plates -, are joined together with the aid of an adhesive frame. The layer thickness is 1.3 μm. The adhesive is cured by careful heating, the liquid crystal mixture from example 1 is filled in at 100°C and the cell is brought to a temperature of 60° by slow cooling. At this temperature, a DC voltage of 4 V is applied and the cooling process is then continued down to 22°C. The DC voltage is switched off. A monostable monodomain is obtained which appears fully dark between crossed polarizers.

The cell is then connected up to square-wave pulses of variable amplitude and the transmission is measured by means of a photodiode and an oscilloscope. The following transmission values are obtained:

Voltage in volts	Transmission = photodiode signal in millivolts
0	1
2	24
3	79
4	129
5	190

After having being connected up, the cell returns to the dark state (0% transmission) once more.

The table below shows the switching time and relaxation time of maximum brightness into the zero state as a function of the applied square-wave voltage:

Voltage in volts	Switching time in milliseconds	Relaxation time in milliseconds
2	2.3	0.34
3	1.9	0.33
4	1.7	0.31
5	1.1	0.29

All values relate to a temperature of 22°C.

Example 3

2-(4-hexyloxyphenyl)-5-octylpyrimidine	18.9% by weight
2-(4-decyloxyphenyl)-5-octylpyrimidine	24.5% by weight
2-(4-octyloxyphenyl)-5-octylpyrimidine	23.6% by weight
2-(2,3-difluoro-4'-pentyl-biphenyl-4-yl)-5-nonyl-pyrimidine	30.0% by weight
(S)-2-fluorodecyl-[4-(5-decylpyrimidine-2-yl) phenyl]ether	3% by weight

The phase sequence is:

isotropic 80°C cholesteric 60°C smectic C*.

The spontaneous polarization is 1.7 nC/cm^2.

Example 4

A glass substrate coated with transparent-conductive indium tin oxide is patterned in a photolithographic process to give an electrode pattern. The transparent conductor tracks of this electrode structure are used for electrically driving the display by means of a function generator and the switching behavior of a thin-film transistor is thus simulated. Two glass plates patterned in this way, which form the upper and lower sides of the display - that is to say the supporting plates -, are joined together with the aid of an adhesive frame. The layer thickness is 1.3 μm. The adhesive is cured by careful heating, the liquid crystal mixture from example 3 is filled in at 100°C and the cell is brought to a temperature of 63°C by slow cooling. At this temperature, a DC voltage of 4 V is applied and the cooling process is then continued down to 22°C. The DC voltage is switched off. A monostable monodomain is obtained which appears fully dark between crossed polarizers.

The cell is then connected up to square-wave pulses of variable amplitude and the transmission is measured by means of a photodiode and an oscilloscope. The following transmission values are obtained:

Voltage in volts	Transmission = photodiode signal in millivolts
0	1
2	108
3	217
4	306
5	392

After having being connected up, the cell returns to the dark state (0% transmission) once more.

The table below shows the switching time and relaxation time of maximum brightness into the zero state as a function of the applied square-wave voltage:

Voltage in volts	Switching time in milliseconds	Relaxation time in milliseconds
2	1.9	0.33
3	1.6	0.29
4	1.4	0.25
5	0.94	0.24

All values relate to a temperature of 22°C.

Patent claims

1. A monostable ferroelectric active matrix display, containing a liquid crystal layer in the form of a monodomain with an unambiguously defined direction of the normal z to the layer of the smC^* phase, wherein the normal z to the layer and the preferential direction n of the nematic or cholesteric phase (N^* phase) form an angle of more than 5°.

2. The active matrix display as claimed in claim 1, wherein the angle between the normal z to the layer of the smC^* phase and the preferential direction n of the nematic or cholesteric phase (N^* phase) lies in a range of from 0.5 times to 1.0 times the smC^* tilt angle.

3. The active matrix display as claimed in claim 1 or 2, wherein the ferroelectric liquid crystal layer has a phase sequence of

$$I^*-N^*-smC^*$$

where there may be an smA^* phase having a range of existence of at most 2°C between the N^* phase and the smC^* phase.

4. The active matrix display as claimed in one of claims 1 to 3, wherein the spontaneous polarization of the ferroelectric liquid crystal phase is less than 15 nC/cm^2.

5. The active matrix display as claimed in one of claims 1 to 4, wherein, in the liquid crystal layer, the length of the chiral-nematic or cholesteric pitch in a temperature range of at least 2°C above the transition to the smectic phase is more than 50 μm.

6. A process for producing active matrix displays as claimed in one of claims 1 to 5, in which the liquid crystal layer is introduced into the interspace between a rubbed upper substrate plate and a rubbed lower substrate plate of the active matrix display, the rubbing directions on the

upper and lower substrate plates being essentially parallel, and the liquid crystal phase is cooled from the isotropic phase, an electric DC voltage being applied to the display at least during the $N^* \rightarrow smC^*$ or $N^* \rightarrow smA^* \rightarrow smC^*$ phase transition.

7.   An active matrix display, producible according to the process as claimed in claim 6.

8.   The use of active matrix displays as claimed in one of claims 1 to 5 and 7 in the TV, HDTV or multimedia field or in the field of information processing.

9.   The use as claimed in claim 8 in Notebook PCs, personal digital assistants and desktop monitors.

Abstract

The monostable ferroelectric active matrix display contains a liquid crystal layer in the form of a monodomain with an unambiguously defined direction of the normal z to the layer of the smC^* phase and is characterized by the fact that the normal z to the layer and the preferential direction n of the nematic or cholesteric phase (N^* phase) form an angle of more than 5°.

DECLARATION FOR PATENT APPLICATION AND POWER OF ATTORNEY
(Includes reference to PCT International Applications)

FROMMER LAWRENCE & HAUG, LLP
File No.: 514453-3853

As a below named inventor, I hereby declare that:

My residence, post office address and citizenship are as stated below next to my name.

I believe I am an original, first and joint inventor (if plural, names are listed below) of the subject matter which is claimed and for which a patent is sought on the invention ENTITLED:

MONOSTABLE FERROELECTRIC ACTIVE MATRIX DISPLAY

the specification of which:

X	is attached hereto
X	was filed on 11/16/00 09/700,517
X	United States Application Serial No. _____
	PCT Application No. filed PCT/EP99/03437
	with amendments through_____(if applicable, give details).

I hereby state that I have reviewed and understand the contents of the above-identified specification, including the claims, as amended by any amendment referred to above.

I acknowledge the duty to disclose to the United States Patent and Trademark Office all information known to me to be material to patentability as defined in Title 37, Code of Federal Regulations, § 1.56.

I hereby claim foreign priority benefits under Title 35, United States Code § 119 (a) - (d) or § 365 (b) of any foreign application(s) for patent or inventor's certificate, or § 365 (a) of any PCT International application(s) designating at least one country other than the United State of America listed below and have also identified below any foreign application for patent or inventor's certificate or any PCT International applications designating at least one country other than the United States of America filed by me on the same subject matter having a filing date before that of the application(s) on which priority is claimed:

Prior Foreign/PCT Application(s) [list additional applications on separate page]:

Country (or PCT)	Application Number:	Filed (Day/Month/Year)	Priority Claimed: Yes	No
Germany	198 22 830.9	May 20, 1998	X	

I hereby claim the benefit under 35 U.S.C. § 119(e) of any United States provisional application(s) listed below.

I hereby claim the benefit under Title 35, United States Code § 120 of any United States application(s) or § 365 (c) of any PCT international application(s) designating the United States of America that is/are listed below and, insofar as the subject matter of each of the claims of this application is not disclosed in that/those prior United States or PCT International application(s) in the manner provided by the first paragraph of Title 35, United States Code § 112, I acknowledge the duty to disclose to the United States Patent and Trademark Office all information known to me to be material to patentability as defined in Title 37, Code of Federal Regulations, § 1.56 which became available between the filing date of the prior application and the national or PCT international filing date of this application:

Prior U.S. (or U.S.-designating PCT) Application(s) [list additional applications on separate page]:

U.S. Serial No.:	Filed (Day/Month/Year)	PCT Application No.	Status (patented, pending, abandoned)
PCT	May 19, 1999	PCT/EP99/03437	pending

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I hereby appoint William F. Lawrence, Registration No. 28,029, and FROMMER LAWRENCE & HAUG, LLP or their duly appointed associates, my attorneys or agents, with full power of substitution and revocation, to prosecute this application, to make alterations and amendments therein, to file continuation and divisional applications thereof, to receive the Patent, and to transact all business in the Patent and Trademark Office and in the Courts in connection therewith, and to insert the Serial Number of the application in the space provided above, and specify that all communications about the application are to be directed to the following correspondence address:

William F. Lawrence, Esq.
c/o FROMMER LAWRENCE &
HAUG, LLP
745 Fifth Avenue
New York, NY 10151
FAX (212) 588-0500

Direct all telephone calls to: (212) 588-0800
to the attention of:
William F. Lawrence

I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.

INVENTOR(S):

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NOTE: In order to qualify for reduced fees available to Small Entities, each inventor and any other individual or entity having rights to the invention must also sign an appropriate separate "Verified Statement (Declaration) Claiming [or Supporting a Claim by Another for] Small Entity Status" form [e.g. for Independent Inventor, Small Business Concern, Nonprofit Organization, Individual Non-Inventor].

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